Research Article

Impact of bladder, bowel and sexual dysfunction on health status of people with thoracolumbar spinal cord injuries living in the community

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Objective. The disruption of autonomic function following a spinal cord injury (SCI) is common and can negatively affect quality of life. The objective of this study was to describe the prevalence of bladder/bowel incontinence and sexual dysfunction in community-dwelling individuals with a thoracolumbar SCI and examine the impact on general physical and mental health status.

Methods. Participants who sustained a traumatic SCI to the thoracolumbar region of the spinal cord and classified as American Spinal Injury Association Impairment Scale (AIS) A to D were recruited. Demographic, injury data, MRI classification and neurological data were collected on admission. At follow-up, the neurological data, a questionnaire collecting participant-reported secondary health conditions (SHCs) (e.g. bladder incontinence, depression etc.) following SCI and health status measured by Short Form-36 were obtained. Regression models determined the association of health status with demographic/injury-related data, types and number of SHCs.

Results. Of the 51 participants, 58.8% reported bladder incontinence, 54.0% bowel incontinence, 60.8% sexual dysfunction and 29.4% had all three. The regression models demonstrated that age at injury, bowel incontinence, sexual dysfunction, presence of pain, motor score at follow-up and the number of SHCs were significant predictors of health status. The number of SHCs was more predictive than all other demographic and injury variables for health status.

Conclusion. Results highlight the high prevalence of self-reported bowel/bladder incontinence and sexual dysfunction in the traumatic thoracolumbar SCI population and support the need for standardized assessments. Several demographic, injury-related and SHCs impacted health status and should be considered for the management of individuals living in the community.

Keywords: Fecal incontinence, Quality of Life, Sexual dysfunction, Spinal cord injuries, Urinary incontinence

Introduction

Beyond the motor and sensory impairment that occurs following a spinal cord injury (SCI), individuals suffer from multiple secondary health conditions (SHCs), which can include pre-existing comorbidities (e.g. depression) and secondary complications such as bladder dysfunction due to impaired autonomic function. The thoracolumbar junction where the distal spinal cord transitions to conus medullaris and then onto cauda equina is of particular interest for bladder, bowel and sexual dysfunction since

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the lumbar sympathetic, sacral parasympathetic and sacral somatic nerves responsible for these functions are located in this region of the spinal cord.[1] An injury at this location increases a person's susceptibility to bladder, bowel and sexual dysfunction and addressing these problems is a high priority for individuals with SCI[2,3] given the negative impact on an individual's quality of life.[4–8]

Despite the importance of bladder, bowel and sexual function on the quality of life,[3,5,9,10] prevalence in people who sustain a SCI at the thoracolumbar junction and the long-term recovery of these functions is not well established. Of the three dysfunctions, bladder dysfunction is the best described, although the prevalence within this population is highly variable. A review of studies focusing on cauda equina injuries caused by lumbar disc herniation alone reported a prevalence that ranged between 13–90% with an average follow-up of 17 months.[11] From a clinical management perspective, studies have highlighted that neurologic recovery does not correspond to improvement in voiding function[12,13] and that commonly used neurological indicators, such as pinprick sensation and bulbocavernosus reflex, are not predictors for bladder recovery.[13,14]

Less is known about bowel or sexual dysfunction in this patient population; the prevalence is reported to be high but varies among the studies,[15–17] likely a result of differing definitions, metrics, follow-up times and measures utilized. McCarthy *et al.* studied a group of individuals with cauda equina syndrome as a result of prolapsed discs and found that reduced perianal sensation continued in 66% of individuals at follow-up (mean 60 months) and that 60% complained of bowel disturbance.[16] In the same population, 30% of the males had complete inability to have an erection and 17% had difficulty with erections, while 47% of women had reduced sensation during intercourse and 16% were unable to attain an orgasm.[16] Premature ejaculation has also been associated with lower lesions of the lumbosacral segments.[18] A lab-based study focusing on female arousal found that in women with complete lower motor neuron dysfunction (S2–S5) only 17% were able to achieve orgasm.[19] With respect to sexual dysfunction, the literature predominately focuses on males, with little information available on females.[15,20–22] Given the high prevalence, variable recovery and impact on quality of life, bladder, bowel and sexual health are critical components of rehabilitation for individuals with thoracolumbar SCI (TLSCI) and more research efforts should address the knowledge gaps to support clinical decisions.

The impact of multiple SHCs (also known as multimorbidity) on patient outcomes illustrates one such knowledge gap. Often it is not the impact of individual SHCs, but the combined burden of multiple SHCs that greatly compromises quality of life of persons with SCI.[23] It is plausible to expect an interaction among bladder, bowel and sexual dysfunction in persons with TLSCI based on pathophysiology, but few studies explore such interactions.[16,17,20] Additionally, the prevalence of TLSCI and subsequent dysfunctions in the traumatic SCI population alone are difficult to ascertain since many studies examining this patient population include both traumatic and non-traumatic etiologies. The objective of this study was to describe the prevalence of bladder/bowel incontinence and sexual dysfunction in a community-dwelling sample of individuals with traumatic TLSCI, determine their interaction with each other, with other SHCs and their impact on health status.

Materials and methods

Conceptual model

A conceptual model (Fig. 1) adopted from published literature[8] exploring the effect of SHCs on health status was developed. Other than the three SHCs (bladder/bowel, sexual dysfunction) that were of primary interest, we were also interested in how other SHCs such as pain and depression contributed to health status. For the purpose of this study, we limited the definition of bladder and bowel dysfunction to bladder and bowel incontinence. Although other prevalent SHCs (e.g. pressure ulcers, spasticity) or other aspects of bladder and bowel dysfunctions (e.g. infection) may have an impact on health status, these were not a focus of our study and not included in the model.

Study design and patient population

A cross-sectional follow-up study was conducted with patients admitted to an acute spine center with a TLSCI (T11 to L3) between 1995 and 2005. Additional inclusion criteria were: having lived with TLSCI for a minimum of two years at the time of the follow-up; age 18 years or older; a diagnosis of a motor deficit according to the International Standards for the Neurological Classification of SCI (ISNCSCI)[24] with an American Spinal Injury Association Impairment Scale (AIS) A-D; and participation in a standardized rehabilitation program. Individuals were excluded if they: had organic brain disease, dementia, or head injury precluding completion of the follow-up assessment; a major neurological comorbidity that prevents motor assessment; admission to the acute spine unit greater than 72 hours after injury; or an inability to complete follow-up. A spine database was used to identify eligible participants.

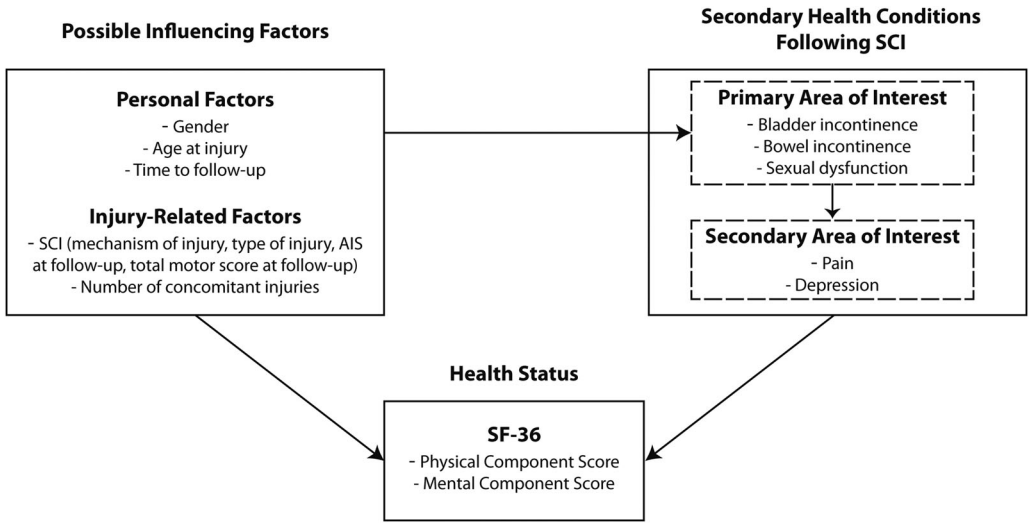

Figure 1 Conceptual model exploring the effect of secondary health conditions on the health status of individuals with traumatic spinal cord injuries.
Abbreviations: American Spinal Injury Association Impairment Scale, AIS; Spinal Cord Injury, SCI; Short Form-36, SF-36.

Data collection

Demographic and injury-related variables such as age, sex and mechanism of injury were obtained from a spine database. Participants were classified into cord, conus or cauda equina injury using Magnetic Resonance Imaging. Neurological impairment was assessed on admission using ISNCSCI by a spinal fellow or a physiotherapist. All follow-up assessments were conducted by a physiotherapist with expertise in SCI who examined participants and participants completed questionnaires. Ethical approval was obtained from the university and hospital. All participants provided informed consent.

Questionnaire

The questionnaire included measures to assess bladder/bowel incontinence, sexual dysfunction, pain, depression and health status. Self-reported prevalence of *bladder incontinence* was measured using question one and two from the inconvenience domain of the Qualiveen measure.[25] Participants were classified as having bladder incontinence if he/she answered "slightly", "moderately", "quite a bit", or "extremely" to question one ("Are you bothered by urine leaks during the day?") or two ("Are you bothered by urine leaks at night?"). Each item is based on a scale with five response options ranging from "not at all (affected)" to "extremely (affected)". "Not applicable" is selected if the participant does not experience any urine leaks.

Self-reported prevalence of *bowel incontinence* was assessed using two questions that were structured similar to the bladder items in the Qualiveen. Participants were classified as having bowel incontinence if they answered "slightly", "moderately", "quite a bit", or "extremely" to question one ("Are you bothered by fecal leaks during the day") or question two ("Are you bothered by fecal leaks at night").

Self-reported prevalence of *sexual dysfunction* was assessed using an 8-item measure for men and women (see Supplementary Material 1). Participants were classified as having a sexual dysfunction if they answered "no" to one or more of the first three items in question eight ("Since my SCI, I am able to: achieve an erection/sexual arousal [warmth or tingling in genitals, lubrication, or muscle contractions]; maintain an erection adequate for intercourse/become lubricated ["wet"] during sexual activity; ejaculate/reach orgasm [climax] with sexual stimulation or intercourse."). All the others were classified as not having sexual dysfunction.

Pain intensity and interference with participation was assessed using the von Korff Pain Rating Scale.[26] Items one to three and five to seven have a response scale ranging from 0 to 10, whereby a higher score reflects more pain. Item four asks the participant to record the number of days in the last six months when he/she was kept from usual activity (work, school, housework) due to pain and subsequently assigns points based on the number of days. More days kept from usual activity

correspond to more points. A pain intensity score is calculated from items one to three and disability points are calculated from items four to seven. The pain is classified using both the pain intensity and disability points. The classification of pain ranges from Grade 0 representing "pain free" to Grade IV representing "high disability severely limiting" pain.

Depression was assessed using the Brief Patient Health Questionnaire-9[27] developed to screen for major depression or other depressive syndromes. Nine questions have a 4-point response options ranging from "not at all (bothered)" to "(bothered) nearly every day". There is an additional question asking about interference of these problems with work, home or relationships, and the response options range from "not difficult at all" to "extremely difficult".

Health status was assessed using the Short Form-36.[28] This measure consists of eight domains (physical function, role physical, mental health, role emotional, vitality, bodily pain, social functioning and general health). They can be reported as a physical component score (PCS) and a mental component score (MCS), which are based on normative data with a mean of 50 points and a standard deviation of 10 points. A higher score reflects better health status.

Data analysis

A univariate analysis was first conducted to determine the distribution of the demographic/injury-related variables and prevalence of SHCs as per the responses to included measures. Participants were then divided into two groups—those who have bladder incontinence and those who do not based on their answers from the Qualiveen. Bivariate analyses compared the two groups for demographic and injury variables such as age at injury, sex, mechanism of injury, admission and follow-up AIS classification, motor score, and presence of other SHCs (e.g. bowel incontinence, pain) at the time of follow-up. For categorical data, the χ^2 test was used unless the expected cell count was less than five, in which case the Fisher's exact test was used. The comparisons between two groups were completed using independent *t*-tests with Levene's test to assess for the equality of variance. If the data were not normally distributed, then the Mann-Whitney *U* test was used. Similar analyses were repeated for participants with bowel incontinence and sexual dysfunction.

To determine which factors were associated with health status (SF-36 PCS and MCS) a multiple linear regression analysis was conducted with demographic and injury variables as well as SHCs following SCI. We included variables that were important ($P < 0.2$) in the bivariate analyses and from expert input on clinically-relevant variables (e.g. sex and pain). In the first model, the dependent variable was SF-36 PCS and MCS and the independent variables were age, sex, bowel/bladder incontinence, sexual dysfunction, pain, motor score at follow-up, mechanism of injury, concomitant injury and AIS at follow-up. To examine the impact of having multiple SHCs, we developed a second model where the dependent variable was also SF-36 PCS and MCS and the independent variables were age, sex, number of SHCs, motor score at follow-up, mechanism of injury, concomitant injury and AIS at follow-up. We checked the distribution of the residuals in all regression models and ensured that they followed a normal distribution. We also checked the heteroscedasticity of the residuals and ensured they met the assumption. All analyses were conducted using SAS Version 9.3 (SAS Institute Inc., Cary, NC, USA) and IBM SPSS Version 23 (IBM Corp, Armonk, NY, USA).

Results

Patient population

Of the 203 eligible individuals, seven died, 49 could not be contacted, and 22 were excluded for having a neurological comorbidity or not having an initial AIS data. Of 125 remaining individuals, 61 returned the questionnaire (49% response rate). Of these 61 individuals, eight had incomplete questionnaires and two were excluded because of inability to accurately determine the level of injury, leaving 51 participants for the analysis (42 males and 9 females). One participant did not complete the bowel questionnaire so 50 participants were included for the analysis involving bowel incontinence. See Table 1 for the included participants' demographic and injury-related details.

Secondary health conditions

The prevalence of self-reported bladder/bowel incontinence and sexual dysfunction were 58.8% (30/51), 54.0% (27/50), and 60.8% (31/51), respectively (Table 1). It was common for participants to report multiple dysfunctions; for example, 29.4% (15/51) of the participants reported having all of bladder/bowel incontinence and sexual dysfunction (Fig. 2).

Characteristics of participants with bladder incontinence, bowel incontinence and sexual dysfunction

Based on the bivariate results, participants with bladder incontinence were more likely to have complete injuries (56.7% AIS A, with bladder incontinence versus 28.6%

Table 1 Description of included participants

	Time-Point	Value
Demographic and Injury Factors		
Male, % (n)	Admission	82.35 (42)
Female, % (n)	Admission	17.65 (9)
Mean Age at Injury, years ± SD	Admission	38.06±14.62
Mean Time of Follow-up, months ± SD	Follow-up	78.82±29.88
Mechanism of Injury, % (n)	Admission	
Transport		29.41 (15)
Fall		47.06 (24)
Other Traumatic Causes		21.57 (11)
Type of Injury, % (n)	Admission	
Spinal Cord		35.29 (18)
Conus Medullaris		39.22 (20)
Cauda Equina		23.53 (12)
AIS on Admission, % (n)	Admission	
A		45.10 (23)
B		15.69 (8)
C		7.84 (4)
D		29.41 (15)
AIS at Follow-up, % (n)	Follow-up	
A		43.14 (12)
B		1.96 (1)
C		9.80 (5)
D		35.29 (18)
E		7.84 (4)
Number of Concomitant Injuries, % (n)	Admission	
0		50.98 (26)
1		29.41 (15)
>1		19.61 (10)
Mean Total Motor Score on Admission± SD	Admission	63.53±16.34
Mean Total Motor Score at Follow-up ± SD	Follow-up	75.12±20.15
Mean Total Motor Score Change ± SD	Follow-up	11.59±12.61
Secondary Health Conditions		
Bladder Incontinence, % (n)	Follow-up	58.82 (30)
Interference during the day, % (n)		56.86 (29)
Interference at night, % (n)		49.02 (25)
Interference both day and night, % (n)		45.10 (23)
Bowel Incontinence, % (n)[a]	Follow-up	54.00 (27)
Interference during the day, % (n)		52.00 (26)
Interference at night, % (n)		34.00 (17)
Interference both day and night, % (n)		32.00 (16)
Sexual Dysfunction, % (n)	Follow-up	60.8 (31)
Able to achieve an erection/sexual arousal, % (n)		54.90 (28)
Able to maintain an erection/become lubricated, % (n)		49.02 (25)
Able to ejaculate/reach orgasm, % (n)		52.94 (27)
Depression, % (n)	Follow-up	5.88 (3)
Pain	Follow-up	88.24 (45)
Grade I,% (n)		50.98 (26)
Grade II, % (n)		27.5 (14)
Grade III,% (n)		3 (1)
Grade IV, % (n)		7.84 (4)
Health Status	Follow-up	
Mean SF-36 Physical Component Score		37.26±10.17
Mean SF-36 Mental Component Score		51.04±11.65

Abbreviations: American Spinal Injury Association Impairment Scale, AIS; Standard Deviation, SD; Short Form-36, SF-36.
[a] Note that for bowel questions, total number of respondents is 50.

AIS A, without bladder incontinence; P = 0.017), have self-reported bowel incontinence (75.9% versus 23.8%; P < 0.001), and more likely to report sexual dysfunction (71.0% versus 29.0%; P = 0.028). Those participants reporting bladder incontinence had a significantly lower SF-36 PCS score (P = 0.017), with approximately seven points less compared to those without. The SF-36 MCS was also lower in those with bladder incontinence compared to those without, but this difference was not statistically significant (P = 0.194) (Table 2).7

Participants with bowel incontinence were more likely to be female (29.6% versus 4.4%; P = 0.03) and have self-reported bladder incontinence (81.5% versus 30.4%; P < 0.001). Those with bowel incontinence

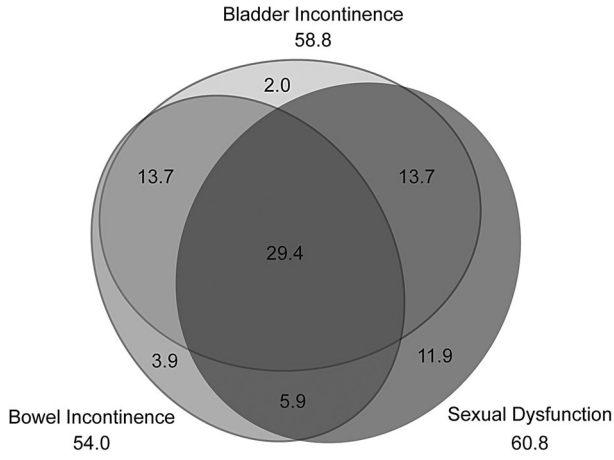

Figure 2 Proportion of the participants reporting bladder incontinence, bowel incontinence and sexual dysfunction and the associated overlap.
Values are given as a percentage of the patient population.

reported a lower SF-36 PCS (P = 0.008) and SF-36 MCS (P = 0.06) compared to those without, but only SF-36 PCS showed statistical significance. Those with no bowel incontinence scored approximately eight points higher on SF-36 PCS than those with bowel incontinence (Table 3).

Participants with sexual dysfunction were significantly more likely to have complete injuries (P < 0.001), approximately twenty-four points lower motor score at follow-up (p=0.002) and bladder incontinence (71.0% versus 40.0%; P = 0.028) compared to those without sexual dysfunction. Those with sexual dysfunction reported a lower SF-36 PCS (P = 0.007) and SF-36 MCS (p=0.111), however only the SF-36 PCS was statistically significant with an approximate 7 point lower score in participants with sexual dysfunction (Table 4).

Factors impacting health status

A multiple linear regression model demonstrated that bowel incontinence (P = 0.007), presence of pain (P < 0.001) and motor score at follow-up (P = 0.009) were significantly associated with the SF-36 PCS. When bowel incontinence and presence of pain increases, the SF-36 PCS decreases; whereas, when motor score at

Table 2 Description of TLSCI participants with bladder incontinence

	No Bladder Incontinence (n=21)	Bladder Incontinence (n=30)	P-Value
Demographic and Injury Factors			
Male, % (n)	90.48 (19)	76.67 (23)	0.277
Female, % (n)	9.52 (2)	23.33 (7)	
Age at Injury, years ± SD	38.44±14.79	37.79±14.75	0.877
Time of Follow-up, months ± SD	81.37±24.42	77.04±33.46	0.473
Energy of Injury, % (n)			0.524
Transport + Other Traumatic Causes	47.62 (10)	52.38 (11)	
Fall	52.38 (11)	43.33 (13)	
Type of Injury, % (n)			0.383
Spinal Cord	33.33 (7)	40.00 (12)	
Conus Medullaris	33.33 (7)	43.33 (13)	
Cauda Equina	33.33 (7)	16.67 (5)	
AIS at Follow-up, % (n)			**0.017***
A	28.57 (6)	56.67 (17)	
B, C	4.76 (1)	16.67 (5)	
D, E	67.67 (14)	26.67 (8)	
Total Motor Score at Follow-up ± SD	80.67±21.40	71.23±18.62	0.110†
Total Motor Score Change ± SD	10.05±11.71	12.67 ± 13.28	0.471
Number of Concomitant Injuries, % (n)			0.214
0	42.86 (9)	56.67 (17)	
1	42.86 (9)	20.00 (6)	
>1	14.29 (3)	23.33 (7)	
Secondary Health Conditions			
Bowel Incontinence, % (n)	23.81 (5)	75.86 (22)	**<0.001*****
Sexual Dysfunction, % (n)	29.0 (9)	71.0 (22)	**0.028***
Depression, % (n)	4.76 (1)	6.67 (2)	0.999
Pain			0.283
Grade 0, I, % (n)	71.4 (15)	56.7 (17)	
Grade II,III&IV, % (n)	28.6 (6)	43.3 (13)	
Health Status			
Mean SF-36 Physical Component Score	41.28±10.22	34.44±9.30	**0.017***
Mean SF-36 Mental Component Score	53.42±8.59	49.38±13.28	0.194†

Abbreviations: American Spinal Injury Association Impairment Scale, AIS; Standard Deviation, SD; Short Form-36, SF-36; P < 0.05 indicated by *, P < 0.01 indicated by **, P < 0.005 indicated by ***, P < 0.2 indicated by †.
[a]Note that P values below the threshold of statistical significance (P < 0.05) have been bolded.

Table 3 Description of TLSCI participants with bowel incontinence

	No Bowel Incontinence (n=23)	Bowel Incontinence (n=27)	P-Value
Demographic and Injury Factors			
Male, % (n)	95.65 (22)	70.37 (19)	**0.028***
Female, % (n)	4.35 (1)	29.63 (8)	
Age at Injury, years ± SD	39.84±14.25	36.36±15.26	0.408
Time of Follow-up, months ± SD	83.70±29.83	73.13±29.01	0.211
Mechanism of Injury, % (n)			0.093†
Transport + Other Traumatic Causes	39.13 (9)	62.96 (17)	
Fall	60.87 (14)	37.04 (10)	
Type of Injury, % (n)			0.751
Spinal Cord	30.43 (7)	40.74 (11)	
Conus Medullaris	43.48 (10)	37.04 (10)	
Cauda Equina	26.09 (6)	22.22 (6)	
AIS at Follow-up, % (n)			0.532
A	39.13 (9)	48.15 (13)	
B, C	8.70 (2)	14.81 (4)	
D, E	52.17 (12)	37.04 (10)	
Total Motor Score at Follow-up ± SD	78.13±20.98	73.37±19.45	0.279
Total Motor Score Change ± SD	10.17±12.27	13.11±13.08	0.371
Number of Concomitant Injuries, % (n)			0.281
0	56.52 (13)	48.15 (13)	
1	34.78 (8)	25.93 (7)	
>1		8.70 (2)	25.93 (7)
Secondary Health Conditions			
Bladder Incontinence, % (n)	30.43 (7)	81.48 (22)	**<0.001****
Sexual Dysfunction, % (n)	40.0 (12)	60.0 (18)	0.297
Depression, % (n)	4.35 (1)	7.41 (2)	0.999
Pain			0.449
Grade 0& I, % (n)	69.57 (16)	59.26 (16)	
Grade II & III&IV, % (n)	30.43 (7)	40.74 (11)	
Health Status			
Mean Short Form-36 Physical Component Score	41.50±10.00	33.84±9.23	**0.008****
Mean Short Form-36 Mental Component Score	54.68±7.29	49.12±12.74	0.060†

Abbreviations: American Spinal Injury Association Impairment Scale, AIS; Standard Deviation, SD; Short Form-36, SF-36; $P < 0.05$ indicated by *, $P < 0.01$ indicated by **, $P < 0.005$ indicated by ***, $P < 0.2$ indicated by †.
[a]Note that P values below the threshold of statistical significance ($P < 0.05$) have been bolded.

follow-up increases so does the SF-36 PCS (Table 5). When looking at variables associated with the SF-36 MCS, the model demonstrated that age at injury ($P = 0.043$), sexual dysfunction ($P = 0.011$) and motor score at follow-up ($P = 0.031$) were significant; when sexual dysfunction and motor score at follow-up increases the SF-36 MCS decreases, whereas when age at injury increases the SF-36 MCS increases (Table 5).

Alternately, to determine the influence of multiple SHCs on health status, we conducted a second multiple regression model where the total number of SHCs was used in place of individual conditions. The number of SHCs was the only variable significantly associated with the SF-36 PCS ($P < 0.001$) and SF-36 MCS ($P = 0.005$). When the number of SHCs increases both the SF-36 PCS and SF-36 MCS decreases (Table 6).

Discussion

The recovery of bladder/bowel continence and sexual function are among the highest priorities for individuals with SCI. Those with TLSCI may have promising neurological prognosis but remain at risk for bladder/bowel incontinence and sexual dysfunction while living in the community. This study found a high prevalence of self-reported bladder/bowel incontinence and sexual dysfunction occurring individually and in combination among community-dwelling individuals with traumatic TLSCI. Individuals reporting bladder incontinence were more likely to report bowel incontinence and sexual dysfunction. Age at injury, bowel incontinence, sexual dysfunction, pain, motor score (at follow-up) and the number of SHCs were significantly associated with health status.

Data on the prevalence of bladder/bowel incontinence and sexual dysfunction among individuals with traumatic TLSCI in the community is scarce as most studies include both traumatic and non-traumatic TLSCI.[11,15–17,29–31] While the prevalence of self-reported bladder/bowel incontinence and sexual dysfunction from our study fits within the range of published literature, a direct comparison is difficult as the definition of dysfunctions, measures used, participant

Table 4 Description of TLSCI participants with sexual dysfunction

	No Sexual Dysfunction (n=20)	Sexual Dysfunction (n=31)	P-Value
Demographic and Injury Factors			
Sex			0.454
Male, % (n)	90.0 (18)	77.4 (24)	
Female, % (n)	10.0 (2)	22.6% (7)	
Age at Injury, years ± SD	33.94±9.34	40.71±16.81	0.071†
Time of Follow-up, months ± SD	82.09±26.19	76.72±32.27	0.536
Mechanism of Injury, % (n)			0.417
Transport + Other Traumatic Causes	60.0 (12)	48.4 (15)	
Fall	40.0 (8)	51.6 (16)	
Type of Injury, % (n)			0.072†
Spinal Cord	25.0 (5)	45.2 (14)	
Conus Medullaris	35.0 (7)	41.9 (13)	
Cauda Equina	40.0 (8)	12.9 (4)	
AIS at Follow-up, % (n)			**0.0002*** **
A	15.0 (3)	64.5 (20)	
B, C	10.0 (2)	12.9 (4)	
D, E	75.0 (15)	22.6 (7)	
Total Motor Score at Follow-up ± SD	89.65±12.61	65.74±18.56	**0.002*** **
Total Motor Score Change ± SD	16.40±11.73	8.48±12.34	0.882
Number of Concomitant Injuries, % (n)			0.245
0	50.0 (10)	51.6 (16)	
1	40.0 (8)	22.6 (7)	
>1	10 (2)	25.8 (8)	
Secondary Health Conditions			
Bladder Incontinence, % (n)	40.0 (8)	71.0 (22)	**0.028***
Bowel Incontinence, % (n)	45.0 (9)	60.0 (18)	0.297
Depression, % (n)	5.0 (1)	6.5 (2)	0.999
Pain			0.789
Grade 0&I, % (n)	65.0 (13)	61.3 (19)	
Grade II & III&IV, % (n)	35.0 (7)	38.7 (12)	
Health Status			
Mean SF-36 Physical Component Score	41.92±10.51	34.25±8.87	**0.007** **
Mean SF-36 Mental Component Score	53.98±7.82	49.15±13.34	0.111†

Abbreviations: American Spinal Injury Association Impairment Scale, AIS; Standard Deviation, SD; Short Form-36, SF-36; P < 0.05 indicated by *, P < 0.01 indicated by **, P < 0.005 indicated by ***, P < 0.2 indicated by †.
[a]Note that P values below the threshold of statistical significance (P < 0.05) have been bolded.

Table 5 Multiple linear regression result with demographic, injury-related and individual secondary health conditions to determine predictors of health status

	SF-36 Physical Component Score[a]	
Variable	β	P-Value
Age at Injury	-0.135	0.087
Bowel Incontinence	-6.449	0.007**
Presence of Pain	-9.129	<0.001***
Motor Score at Follow-up	0.155	0.009**
	SF-36 Mental Component Score[a]	
Variable	β	P-Value
Age at Injury	0.211	0.043*
Sexual Dysfunction	-9.900	0.011*
Motor Score at Follow-up	-0.198	0.031*

Abbreviations: Short Form-36, SF-36; P < 0.05 indicated by *, P < 0.01 indicated by **; P < 0.005 indicated by ***, P < 0.2 indicated by †.
[a] Dependent variable
Note: Sex, bladder incontinence, sexual dysfunction, mechanism of injury, concomitant injury and AIS at follow-up were not significant and excluded from the model with SF-36 Physical Component Score as the outcome. For the SF-36 Physical Component Score the R^2 value was 0.45. Sex, bladder incontinence, bowel incontinence, presence of pain, mechanism of injury, concomitant injury and AIS at follow-up were not significant and excluded from the model with SF-36 Mental Component Score as the outcome. For the SF-36 Mental Component Score the R^2 value was 0.18.

Table 6 Multiple linear regression result with demographic, injury-related and number of secondary health conditions to determine predictors of health status

	SF-36 Physical Component Score[a]	
Variable	β	P-Value
Number of secondary health conditions	-4.445	<0.001***
	SF-36 Mental Component Score[a]	
Variable	β	P-Value
Number of secondary health conditions	-3.396	0.005***

Abbreviations: Short Form-36, SF-36; p<0.05 indicated by *, P < 0.01 indicated by **; P < 0.005 indicated by ***, P < 0.2 indicated by †.
[a] Dependent variable
Note: Age at injury, sex, mechanism of injury, concomitant injury, motor score at follow-up and AIS at follow-up were not significant and excluded from the model with SF-36 Physical and Mental Component Score as the outcome. For the SF-36 Physical Component Scores the R^2 value was 0.33 and for the SF-36 Mental Component Score the R^2 value was 0.15.

populations and follow-up times vary. In our study, the prevalence of self-reported bladder incontinence was 58.8% which fits within the published values that range from 33% to 74% for urinary incontinence[16,17] and a review that reported a mean prevalence of micturition dysfunction of 42.5% (range 13.3–90.0%).[11] The prevalence of self-reported bowel incontinence in our study was 54.0% compared to the literature which reports 31% to 60%.[16,17] For sexual dysfunction, we found a prevalence of 60.8%. Using the International Index of Erectile Function (IIEF), a previous study reported 35%/24% (severe/moderate) sexual dysfunction with only 15% reporting to have normal sexual function,[15] in addition to other studies reporting erectile dysfunction in 84% and 30% of participants.[16,20] Of all the studies mentioned above, only one focuses on the traumatic SCI population.[20] It is unknown whether including the non-traumatic population would impact prevalence and further research is needed for comparison.

In this study we noted that a large proportion of the participants suffer from not just one, but multiple SHCs; over a quarter of the participants (29.4%) reported having all of bladder/bowel incontinence and sexual dysfunction. Physiologically, sympathetic and parasympathetic innervation of the urinary bladder, reproductive organs and lower portion of the digestive system all occur in the same region of the spinal cord (T10-L2 for sympathetic nervous system, S2-S4 for parasympathetic nervous system), suggesting that when there is a lesion to the thoracolumbar region of the spinal cord, all of bladder, bowel and sexual function will be affected simultaneously.[32] In our initial bivariate comparisons, we reported significant association between those reporting bladder incontinence also reporting bowel incontinence ($P < 0.001$) and sexual dysfunction ($P = 0.028$). Few studies report association between these dysfunctions; Barbonetti *et al*. reported on men with concurrent erectile dysfunction and presence of bowel or bladder dysfunction, McCarthy *et al*. reported association between the presence of bowel dysfunction at an initial examination with the development of sexual dysfunction at follow-up, and Podnar *et al*. reported on individuals with urinary symptoms and the interference with their sexual life, but there has not been a study to explore how such combinations of dysfunctions affect an individual's health status.[16,17,20] To our knowledge, there is also no study looking at the proportion of the samples having all of these dysfunctions. Figure 2 shows the proportions of participants in the present study with bladder/bowel incontinence and sexual dysfunction—individually and in combination. The largest proportion of the population occurs when these SHCs are in combination. A larger study using validated measures is needed to confirm the associations reported in our study.

Recently, there have been several community-based surveys that give insight into the high incidence and co-occurrence of SHCs following SCI.[23,33–36] Compared to the present study, the surveys encompass all spinal cord injuries and may not include detailed neurological data. The Swiss SCI cohort study, found a clustering of the most common SHCs (spasticity, pain, sexual, bowel, bladder and urinary tract infection) and a high number of concurrent SHCs (mean 6.3–7.1).[35] Within the same cohort, sexual dysfunction was more common in those with paraplegia and with complete injuries; and 80% of those with sexual dysfunction were not receiving treatment, although the reason why was not ascertained.[35] A study focussing on sexual satisfaction and quality of life found that having other SHCs (bladder and bowel management, pressure ulcers, spasticity or pain) correlated with lower satisfaction with sexual life.[37]

It is well known that individuals with SCI report lower health status when compared to normative values or healthy controls, or even when compared to those with different types of health conditions.[38–41] Also noted in the literature is that SHCs, often measured by Charlson Comorbidity Index[42] or presence of secondary complications, have a consistent significant association with lower health status.[39–41,43–46] To improve mortality prediction in trauma patients, the addition of the number of pre-existing comorbidities has been suggested.[47] In the traumatic SCI population, it appears that having multiple SHCs (pre-existing comorbidities and secondary complications) have a greater negative impact on individual's quality of life than any particular secondary complication.[23] Our study supports this literature and found a significant association between the number of self-reported SHCs (bladder/bowel incontinence, sexual dysfunction, pain and depression) in our patient population with a lower SF-36 PCS and SF-36 MCS. When the number of SHCs was added as an independent variable in our multiple linear regression, all the other variables were excluded showing that the number of SHCs is more predictive than all other demographic and injury variables for health status. This result suggests that from a clinical management perspective focusing on reducing the number of SHCs could improve the health status of individuals who have sustained a traumatic TLSCI and are living in the community.

Of interest in this cohort was the negative association between motor score at follow-up and SF-36 MCS, such that as muscle strength increased in participants, the mental well-being decreased. The hypothesis behind this unexpected association is that participants with more severe injuries adapt and accept their injury and level of function, whereas participants with less severe injuries have higher expectations for recovery that may not be met. This trend, commonly referred to as a response shift, has also been reported in area of health-related quality of life.[48,49] Future planned work will test this hypothesis in a SCI patient registry cohort.

It is important to consider the limitations when interpreting the results of this study. The sample size used in this study was small. This is a problem consistently seen in prospective studies with a TLSCI population, as this injury has low incidence; prevalence of cauda equina and conus medullaris injuries is 8.9 and 4.5 per 100,000, respectively.[50] Future studies using data from SCI registries or prospective multi-center studies are needed. Also, we used the sexual health and bowel measures available to us at the time, as no other measures met our needs. Since then, International SCI Basic Data Sets, including those on female sexual and reproductive function,[51] male sexual function,[52] lower urinary tract function,[53] and bowel function[54] have been published to facilitate comparative studies. Given the high prevalence of low testosterone in males following SCI,[55,56] future studies including testosterone levels with sexual and quality of life questionnaires in male participants could provide additional information regarding the contribution to low sexual drive and quality of life.

Conclusions

In conclusion, people with traumatic TLSCI living in the community reported a high prevalence of bladder/bowel incontinence and sexual dysfunction separately and in combination. In particular, age at injury, bowel incontinence, sexual dysfunction, pain, lower motor score (at follow-up) and the number of SHCs could have an impact on health status. Future studies using validated questionnaires or the International SCI Data Sets are needed to further investigate the multiple associations among SHCs in people with TLSCI.

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